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(56)参考文献　特開　昭61－140802（ＪＰ，Ａ）
特表　昭56－500975（ＪＰ，Ａ）

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(54)【発明の名称】　光学式計測装置



(57)【特許請求の範囲】

【請求項１】くさび型ビームスプリッタ（７）及び実質的に同一のくさび角及び厚さに形成された補正板（９）を有し、この補正板は上記ビームスプリッタ（７）によって導かれるビーム変位及び偏向を中和することを特徴とするマイケルソン干渉計。

【請求項２】上記ビームスプリッタ（７）と上記補正板（９）は、同一の板から製造されることを特徴とする請求項１に請求したマイケルソン干渉計。

【請求項３】前記共通な板は、同一方向を方向付ける機能（＊）とその後端部とを有し、分離された後、ビームスプリッタと補正板とに分割されることを特徴とする請求項２に請求したマイケルソン干渉計。

【請求項４】前記同一方向を方向付ける機能は、面取りによって構成されることを特徴とする請求項３に請求したマイケルソン干渉計。



【請求項５】前記ビームスプリッタ板（７）のくさび角の方向は、出射される時には色補正のために選択され、反射光ビームは、ビームスプリッタ板の概ね中心から対称に排出されることを特徴とする請求項１に請求したマイケルソン干渉計。

【請求項６】前記ビームスプリッタ板（７）の厚さは、不所望な多重反射が検出器（49）上に位置されないよう規定されることを特徴とする請求項１に請求したマイケルソン干渉計。

【請求項７】反射手段（47）は、干渉計ブロック（59）から離れた位置に干渉光を提示できることを特徴とする請求項１に請求したマイケルソン干渉計。

【発明の詳細な説明】

この発明は、光学式計測装置、詳細には、レーザ干渉

計に関する。

光の干渉は、長さの計測に広く利用され、レーザ放射の可干渉性は、フリンジ計数装置の計測範囲を空気中において50メートル以上にできる。最も一般的に利用される放射光原は、周波数安定しているヘリウム－ネオンレーザである。これらの装置は、市中で容易に入手可能で、周波数は、レーザ管の寿命の範囲で、$10^8$分の１程度より多く変化することはない。干渉計を用いて、大気中で、放射の波長によって長さを計測する際には、空気の屈折率の補正が必要になる。この屈折率の補正を可能にするために、大気圧、温度及び湿度を測定することでエドレンの（Edlen′ s）方程式を用いて屈折率量を計算する、及び、干渉屈折計を用いて直接計測する、２つの方法が現在利用されている。上記計算された量と計測された量との比較の結果、上記計算された量に、上記空気の屈折率として$\pm 10^7$分の１の誤差が認められている。この誤差は、屈折率計が利用されることで$10^8$分の１まで低減できる。

光路長の変化から発生される電気信号を解析する電気的装置を利用し、温度、振動及び気流などの障害を低減できる干渉計装置を用いることで、ナノメータ単位（sub－nanometric）の分解能を与えることができる。その一方で、高解像度を正確に実現するに際して、２つの基本的な装置的制約がある。

多くの干渉計装置は、光学出力端から戻されるフリンジを計数するために要求される電気信号を引出すために偏光（を利用した技術）を利用している。この信号は、光路差に関連して正弦的になるとともに、理想的には、増幅度及び直角位相の直流レベルは、０を示す。現実には、これらの信号は、理想と異なり、（この誤差は）干渉計装置によるナノメータ単位の精度での分解に際して、正確さの点で制約を加える。十分に間隔があけられたオルソゴナル（結晶板に対して平行に入射される）偏光ビームによって設計された薄膜偏光ビームスプリッタは入手困難であるから、光成分の偏光アジマスの整列（精度）を要求することは難しい。しかしながら、現実には、光信号を電気的に補正する装置が可能である。このことは、信号の増幅度と直流レベルの双方の多くの変化が計算された少なくとも１つのフリンジと試験位相によって干渉計の光路を走査することで、及び、干渉計（からの）信号の正弦量を確認することで、達成される。

散発的な反射も、干渉計装置における精度及び分解能の双方を達成することに対して、著しい装置的制約を与える。レーザ光源は、可干渉性の高い不所望なビーム、即ち、干渉計信号に含まれ、ビーム強度で10%を占める不規則出力及び測定された光路長における1.6nmの非線形誤差を伴っている。

英国特許第2012450Bには、板状ビームスプリッタが利用されている干渉計（以下、NPL干渉計とする）が開示されている。上記NPL干渉計は、この種の干渉計としての標準プラクティスであって、僅かにウェッジング（くさび形の傾斜）が与えられたビームスプリッタによる、或いは、標準的な反射防止コーティングが施されている非ビームスプリッタ面からの反射の影響を最小にできる。後述（ウェッジングされたビームスプリッタに関する）のプラクティスは、解像力の問題に対してもっと有益である。ロウェリ（Rowley）の方程式（WRC Rowley “Single strength in two－beaminterferometers with laser illumination"Optica Acta16,<1969>159－168）には、ビームの発散は、１＋0.5分の弧のくさびによって導かれるフリンジと1mm直径の開口が直交することで生じるガウス分布は、散発的な反射によって光検出器上に投影されるナノメータ単位（nanometric）のインターフェログラムの位相の影響以下となることを示している。

しかしながら、ウェッジングは、散発的な反射によって生じる新らたな問題即ちビームスプリッタからウィーク（屈折力が僅かな）プリズムへの戻りを除去できる。この残留ビームによる発散は、光ビームと機械軸との移動を整合させるためにビームスプリッタが位置されるべき条件のもとで、プレートに対する入射角45゜に起因する変位を伴う。プラクティスでは、上記整合を得ることは非常に困難であって、加えて、特別な厚さ及びくさび角に形成されたビームスプリッタが交差させることはできない（防止される）。ナノメータ単位の解像力を提供するために、ビームスプリッタ板を含む干渉計装置、ビームスプリッタ及び補正板装置が既に考案されている。

この発明によれば、くさび型ビームスプリッタ及び実質的に同一のくさび角及び厚さに形成された補正板を有し、この補正板は上記ビームスプリッタによって導かれるビーム変位及び偏向を中和することを特徴とするマイケルソン干渉計が提供される。

このことは、干渉計ブロックが装置に統合的整合を残す前に、装置の光学軸及び機械軸の双方を最適に整合できる。

以下の図面を参照して、この発明の実施例を詳細に説明する。図１は、この発明の一実施例に関するマイケルソン干渉計を概略的に示す。図２は、図１の干渉計のためのビームスプリッタ及び補正板を示す、及び、図３は、この発明の別の実施例に関する干渉計測長装置を示す。

図面を参照すれば、図１は、補正板を含むマイケルソン干渉計を示している。レーザ源からの放射は、レーザビーム１として干渉計に入射する。レーザビーム１は、くさび形プリズム７を介して透過ビーム３と反射ビーム５に分離される。透過ビーム３は、くさび型補正板９を通過し、再帰反射装置11（へ到達し）及びくさび型補正板９を経てビームスプリッタへ再び戻される。反射ビーム５は、再帰反射装置13によってさらに反射されて再び

ビームスプリッタ7を通過し、透過ビーム3が反射された（ビーム）と結合され、2つの干渉（ビーム）15及び17を型づくる。補正板として機能する1枚の板は、ビームスプリッタ板によるビーム変位及び偏向を中和する。

ビームスプリッタ板は、必要な大きさの2倍形成される。このビームスプリッタ板は、等しい大きさのパートA及びBに分割され（図2a）、図2bに示されている光学的配置で利用される。このことは、ビームが導かれるビームスプリッタ板（some means）に関し、方向性（図において＊によって示されている端部の配置）を明確にできることが重要となり、例えば、切断する以前に、2つの角の一端（即ちある側）を僅かに面取りするなどが好ましい。

この配列は、オルソゴナル板のくさび角及び厚さを無意味なものとする（補正の必要を除去できる）。この干渉計装置は、進行する及び反射された光ビームをビームスプリッタ板の中心に関して対称に排出することから、ビームスプリッタ板のくさびの方向がビームの配列によって制限された場合であっても、常に色補正可能である。このことは、多波長光源に対しても有益である。19,21及び23が符されている非ビームスプリット面からの主散乱の反射が図1に点線で示されている。光線2及び3は、逸脱される、が、しかし、このことは重要であって、ビームスプリッタのエッジは、主干渉光と反射（光）1との間のいかなる角度の偏向も入射させない。＊その一方で、2つの相対的に低い輝度を有する反射の変化による不所望な潜在光源であって、1％程度で、光検出器に入射しない位置に配置され、ビームスプリッタ板の厚さが数ミリの際には、有益である。

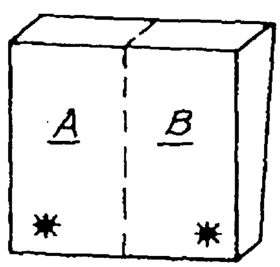
この発明の別の形態として、干渉計ブロックから離れて供試される2つの干渉光を測定できる反射装置（図3に示されている）が追加されることで変形された測長干渉計がある。

この装置では、入射レーザビーム31は、透過ビーム33と反射ビーム35とにくさび型ビームスプリッタ37を介して分離される。透過ビーム33は、くさび型補正板39を通過され、移動可能な再帰反射装置41に導かれる。反射ビーム35は、λ/8位相板43を通過され、再帰反射装置45に導かれた後ビームスプリッタへ入射される。反射装置47は、透過干渉光及び反射干渉光の双方を、偏光子55及びビームスプリッタ57を従えるとともに等しい距離隔てられている光検出器49,51及び53に入射させる。

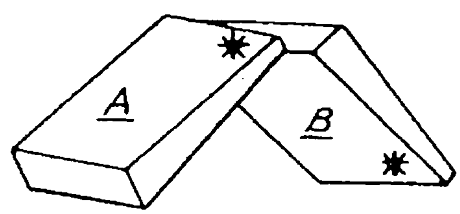
この配置は、重要な装置を干渉計ブロック59に載置可能である。

干渉計から供給される正弦的に変化する光路長信号の電気的解析によって、ナノメータ単位の精度及び解像力を達成できる。その一方で、機械的誤差を引起こす散乱反射は、光検出器に到達する多くの散乱光の波面を傾かせる光学配置及びこの装置の精度によって、解消される。

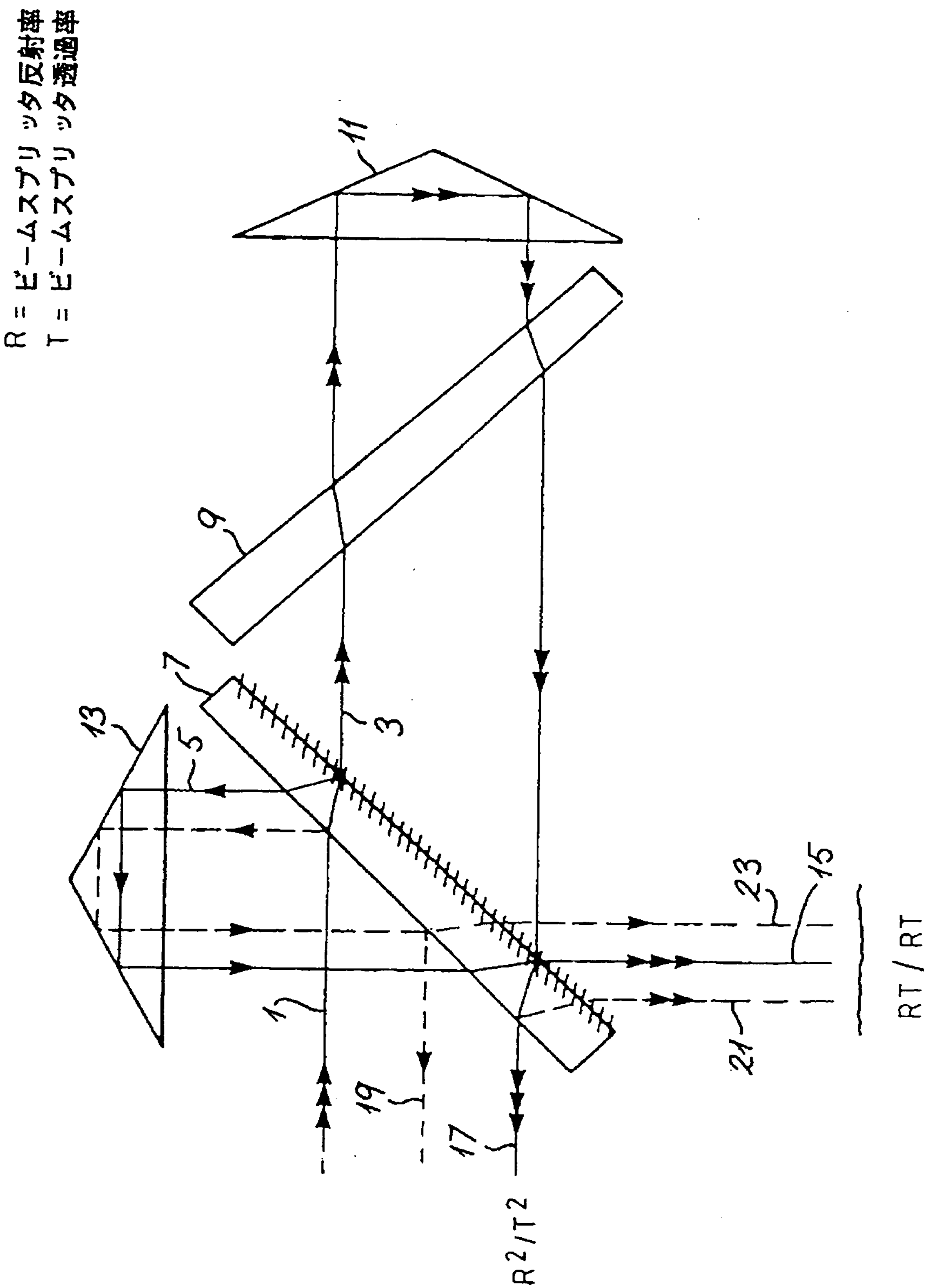
【第2a図】



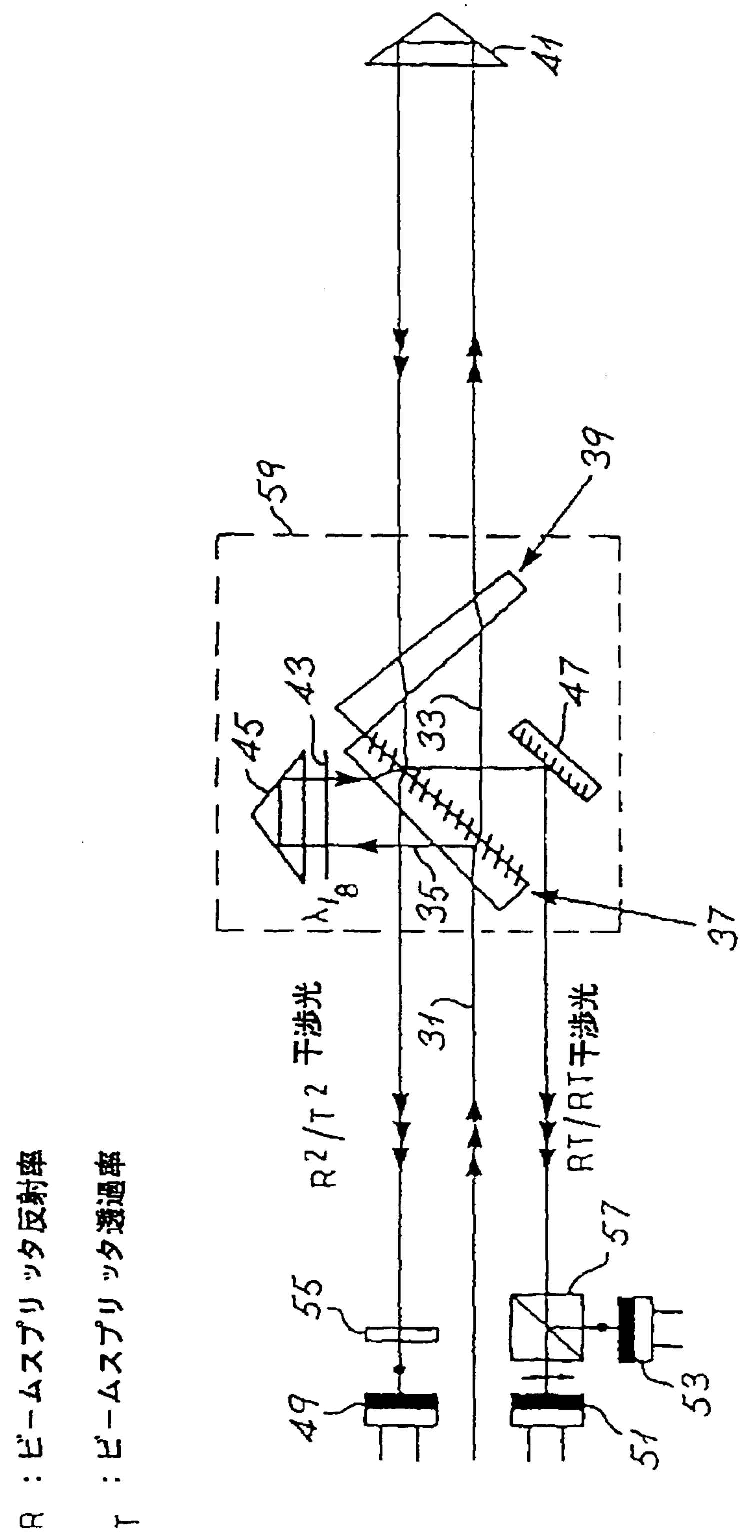

【第2b図】



【第１図】


R = ビームスプリッタ反射率
T = ビームスプリッタ透過率
11
9
7
13
5
3
1
19
17
23
15
21
RT / RT
R2/T2

【第３図】


41
59
39
43
45
47
33
35
37
λ/8
31
R²/T２ 干渉光
RT/RT干渉光
55
57
49
51
53
R：ビームスプリッタ反射率
T：ビームスプリッタ透過率

フロントページの続き

(58)調査した分野(Int.Cl.$^{7}$，ＤＢ名)
G01B 9/00 - 11/30 102

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CLAIMS

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(57) [Claim(s)]
[Claim 1] the beam to which it has a wedge mold beam splitter (7) and the compensation plate (9) substantially formed in the same wedge angle and thickness, and this compensation plate is led by the above-mentioned beam splitter (7) -- the Michelson interferometer characterized by neutralizing a variation rate and a deflection.
[Claim 2] The above-mentioned beam splitter (7) and the above-mentioned compensation plate (9) are the Michelson interferometer for which claim 1 characterized by being manufactured from the same plate was asked.
[Claim 3] Said common plate is the Michelson interferometer for which had the function (*) to orient the same direction, and its back end section, and claim 2 characterized by being divided into a beam splitter and a compensation plate was asked after dissociating.
[Claim 4] The function to orient said same direction is the Michelson interferometer for which claim 3 characterized by being constituted by beveling was asked.
[Claim 5] Said beam splitter plate (7) It is the Michelson interferometer which it was chosen for color correction when outgoing radiation of the direction of the rust angle which goes away was carried out, and asked for the reflected light beam claim 1 characterized in general by the thing of a beam splitter plate discharged by the symmetry from a core.
[Claim 6] The thickness of said beam splitter plate (7) is the Michelson interferometer for which claim 1 characterized by being specified that a multiple echo [ **** / un-] is not located on a detector (49) was asked.
[Claim 7] A reflective means (47) is the Michelson interferometer for which claim 1 characterized by the ability to show the location distant from the interferometer block (59) an interference light was asked.

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[Translation done.]

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## DETAILED DESCRIPTION

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[Detailed Description of the Invention]
This invention relates to an optical metering device and a detail at a laser interferometer.
Interference of light is widely used for measurement of die length, and the measurement range of a fringe counter is made in 50 meters or more by the coherency of laser radiation into air. Radiation Mitsuhara most generally used is He Ne laser which is carrying out frequency stability. These equipments are easily available in the city, and a frequency is the range of the life of laser tubing, and do not change about from 1/108. [ many ] In case die length is measured with the wavelength of radiation in atmospheric air using an interferometer, amendment of the refractive index of air is needed. In order to enable amendment of this refractive index, and it calculates the amount of refractive indexes using Ed Wren's equation (Edlen's) by measuring atmospheric pressure, temperature, and humidity, current utilization of the two approaches of measuring directly using an interference refractometer is carried out. The error of 1/107 [ **] is accepted in the amount by which count was carried out [ above-mentioned ] as a refractive index of the above-mentioned air as a result of the comparison with the amount by which count was carried out [ above-mentioned ], and the measured amount. This error can be reduced to 1/108 by a refractive-index meter being used.
The electric apparatus which analyzes the electrical signal generated from change of the optical path length can be used, and the resolution of a NANOMETA unit (sub-nanometric) can be given by using the interferometer equipment which can reduce failures, such as temperature, an oscillation, and an air current. On the other hand, it faces realizing high resolution to accuracy, and there is two fundamental equipment-constraint.
Many interferometer equipments use polarization (used technique), in order to pull out the electrical signal demanded in order to carry out counting of the fringe returned from an optical outgoing end. While this signal becomes in sine in relation to the optical path difference, ideally, the direct current level of amplification degree and a quadrature phase shows 0. Actually, unlike an ideal, these signals add constraint in respect of accuracy on the occasion of decomposition in the precision of the NANOMETA unit by interferometer (this error) equipment. Since the thin film polarization beam splitter designed by the orthochromatic GONARU (incidence is carried out to parallel to crystal plate) polarization beam in which spacing was fully opened is difficult to receive, it is difficult for it to require alignment (precision) of the polarization azimuth for Mitsunari. However, the equipment which amends a lightwave signal electrically is possible actually. this is scanning the optical path of an interferometer with the amplification degree of a signal, at least one fringe by which many change of the both sides of direct current level was calculated, and trial phase, and is checking the simple harmonic quantity of an interferometer signal (from), and is attained.
A sporadic echo also gives remarkable equipment-constraint to attaining the both sides of the precision in interferometer equipment, and resolution. The laser light source was contained in the coherent high beam [ **** / un-], i.e., interferometer signal, and is accompanied by the 1.6nm nonlinear error in the optical path length who occupies 10% by beam reinforcement and who was measured [ who were measured and was irregular-outputted ].
The interferometer (it considers as a NPL interferometer hereafter) with which the tabular beam splitter is used is indicated by British patent the 2012450B. The above-mentioned NPL interferometer is standard plaque TISU as this kind of an interferometer, and effect of reflective from the non-beam splitter side where standard antireflection coating is performed according [ or ] to the beam splitter to which WEJJINGU (wedge-shaped dip) was given slightly is made as for it to min. Plaque TISU of the after-mentioned (related with the beam splitter [ WEJJINGU / beam splitter ]) is more useful to the problem of resolution. The equation of ROWERI (Rowley) () [ WRC ] Rowley"Single strength in two-beaminterferometers To with laser illumination"Optica Acta 16< 1969>159-168, divergence of a beam The Gaussian distribution produced because opening of the fringe drawn by the wedge of the arc for 1 +0.5 minutes and 1mm diameter intersects perpendicularly Becoming below the effect of the phase of the interferogram of the NANOMETA unit (nanometric) projected by sporadic echo on a photodetector is shown.
However, WEJJINGU can remove the return of the new shelf problem, i.e., the week (refractive power is slight) prism from a beam splitter, produced by sporadic echo. In order that the divergence by this residual beam may

adjust migration with a light beam and a machine shaft, it is the basis of conditions in which a beam splitter should be located, and is accompanied by the variation rate resulting from 45 degrees of incident angles over a plate. The beam splitter formed in special thickness and a wedge angle by acquiring the above-mentioned adjustment very difficult cannot make it cross in plaque TISU (prevented). In order to offer the resolving power of a NANOMETA unit, the interferometer equipment, the beam splitter, and compensation plate equipment containing a beam splitter plate are already devised.
the beam to which according to this invention it has a wedge mold beam splitter and the compensation plate substantially formed in the same wedge angle and thickness, and this compensation plate is led by the above-mentioned beam splitter -- the Michelson interferometer characterized by neutralizing a variation rate and a deflection is offered.
This can adjust the both sides of the optical axis of equipment, and a machine shaft the optimal, before an interferometer block leaves integrative adjustment to equipment.
The example of this invention is explained to a detail with reference to the following drawings. Drawing 1 shows roughly the Michelson interferometer about one example of this invention. Drawing 2 shows the beam splitter and compensation plate for the interferometer of drawing 1, and drawing 3 shows the interference measurement length equipment about another example of this invention.
If a drawing is referred to, drawing 1 shows the Michelson interferometer containing a compensation plate. Incidence of the radiation from the source of laser is carried out to an interferometer as a laser beam 1. A laser beam 1 is divided into a transmitted beam 3 and the reflective beam 5 through the wedge shape prism 7. A transmitted beam 3 passes the wedge mold compensation plate 9, and is again returned to a beam splitter through the recursive reflector 11 (reaching) and the wedge mold compensation plate 9. with the recursive reflector 13, it is reflected further, and the reflective beam 5 passes a beam splitter 7 again, and a transmitted beam 3 reflects it -- having had (beam) -- it joins together -- having -- two interference (beam) 15 and 17 -- ********. the beam according [ one plate which functions as a compensation plate ] to a beam splitter plate -- a variation rate and a deflection are neutralized.
The magnitude which needs a beam splitter plate is 2-double-formed. This beam splitter plate is divided into PERT A and B of equal magnitude (drawing 2 a), and is used by the optical arrangement shown in drawing 2 b. Before it becoming important that directivity (arrangement of the edge shown by * in drawing) can be clarified about the beam splitter plate (some means) to which a beam is led, for example, cutting this, it is desirable to bevel slightly the end (namely, a certain side) of two angles etc.
This array makes meaningless the wedge angle and thickness of an orthochromatic GONARU plate (the need for amendment is removable). Since it reaches and this interferometer equipment discharges the advancing light beam which was reflected to the symmetry about the core of a beam splitter plate, even if it is the case where the direction of the wedge of a beam splitter plate is restricted by the array of a beam, color correction is always possible for it. This is useful also to the multi-wavelength light source. The echo of the main dispersion from the non-beam split side by which 19, 21, and 23 are **(ed) is shown to drawing 1 by the dotted line. ** which deviates from beams of light 2 and 3 -- however, this is important and the edge of a beam splitter does not carry out incidence of the deflection of what kind of include angle between the main interference light and echo (light) 1. On the other hand, it is the potential light source [ **** / un-] by change of two echoes which have low brightness relatively, and is arranged in the location which does not carry out incidence to a photodetector at about 1%, and it is useful in case the thickness of a beam splitter plate is several mm.
There is a length measurement interferometer transformed by the reflector (shown in drawing 3) which can measure two interference lights left and offered as a sample from an interferometer block as another gestalt of this invention being added.
With this equipment, the incidence laser beam 31 is divided into a transmitted beam 33 and the reflective beam 35 through the wedge mold beam splitter 37. A transmitted beam 33 has the wedge mold compensation plate 39 passed, and is led to the movable recursive reflector 41. After the reflective beam 35 has lambda/8 phase plate 43 passed and is led to the recursive reflector 45, incidence of it is carried out to a beam splitter. a reflector 47 carries out incidence of the both sides of a transparency interference light and a reflective interference light to the equal distance partition ******** photodetectors 49, 51, and 53 while being followed by the polarizer 55 and the beam splitter 57.
This arrangement can lay important equipment in the interferometer block 59.
The electric analysis of the optical-path-length signal which is supplied from an interferometer and which changes in sine can attain the precision and resolution of a NANOMETA unit. The scatter reflection which causes a mechanical error on the other hand is canceled by the precision of the optical arrangement to which the wave front of many scattered lights which reach a photodetector is inclined, and this equipment.

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[Translation done.]

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PRIOR ART

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(-- used technical) is used. While this signal becomes in sine in relation to the optical path difference, ideally, the direct current level of amplification degree and a quadrature phase shows 0. Actually, unlike an ideal, these signals add constraint in respect of accuracy on the occasion of decomposition in the precision of the NANOMETA unit by interferometer (this error) equipment. Since the thin film polarization beam splitter designed by the orthochromatic GONARU (incidence is carried out to parallel to crystal plate) polarization beam in which spacing was fully opened is difficult to receive, it is difficult for it to require alignment (precision) of the polarization azimuth for Mitsunari. However, the equipment which amends a lightwave signal electrically is possible actually. this is scanning the optical path of an interferometer with the amplification degree of a signal, at least one fringe by which many change of the both sides of direct current level was calculated, and trial phase, and is checking the simple harmonic quantity of an interferometer signal (from), and is attained.
A sporadic echo also gives remarkable equipment-constraint to attaining the both sides of the precision in interferometer equipment, and resolution. The laser light source was contained in the coherent high beam [ **** / un-], i.e., interferometer signal, and is accompanied by the 1.6nm nonlinear error in the optical path length who occupies 10% by beam reinforcement and who was measured [ who were measured and was irregular-outputted ].
The interferometer (it considers as a NPL interferometer hereafter) with which the tabular beam splitter is used is indicated by British patent the 2012450B. The above-mentioned NPL interferometer is standard plaque TISU as this kind of an interferometer, and effect of reflective from the non-beam splitter side where standard antireflection coating is performed according [ or ] to the beam splitter to which WEJJINGU (wedge-shaped dip) was given slightly is made as for it to min. Plaque TISU of the after-mentioned (related with the beam splitter [ WEJJINGU / beam splitter ]) is more useful to the problem of resolution. The equation of ROWERI (Rowley) () [ WRC ] Rowley"Single strength in two-beaminterferometers To with laser illumination"Optica Acta 16<1969>159-168, divergence of a beam The Gaussian distribution produced because opening of the fringe drawn by the wedge of the arc for 1 +0.5 minutes and 1mm diameter intersects perpendicularly Becoming below the effect of the phase of the interferogram of the NANOMETA unit (nanometric) projected by sporadic echo on a photodetector is shown.
However, WEJJINGU can remove the return of the new shelf problem, i.e., the week (refractive power is slight) prism from a beam splitter, produced by sporadic echo. In order that the divergence by this residual beam may adjust migration with a light beam and a machine shaft, it is the basis of conditions in which a beam splitter should be located, and is accompanied by the variation rate resulting from 45 degrees of incident angles over a plate. The beam splitter formed in special thickness and a wedge angle by acquiring the above-mentioned adjustment very difficult cannot make it cross in plaque TISU (prevented). In order to offer the resolving power of a NANOMETA unit, the interferometer equipment, the beam splitter, and compensation plate equipment containing a beam splitter plate are already devised.
the beam to which according to this invention it has a wedge mold beam splitter and the compensation plate substantially formed in the same wedge angle and thickness, and this compensation plate is led by the above-mentioned beam splitter -- the Michelson interferometer characterized by neutralizing a variation rate and a deflection is offered.
This can adjust the both sides of the optical axis of equipment, and a machine shaft the optimal, before an interferometer block leaves integrative adjustment to equipment.
The example of this invention is explained to a detail with reference to the following drawings. Drawing 1 shows roughly the Michelson interferometer about one example of this invention. Drawing 2 shows the beam splitter and compensation plate for the interferometer of drawing 1, and drawing 3 shows the interference measurement length equipment about another example of this invention.
If a drawing is referred to, drawing 1 shows the Michelson interferometer containing a compensation plate. Incidence of the radiation from the source of laser is carried out to an interferometer as a laser beam 1. A laser beam 1 is divided into a transmitted beam 3 and the reflective beam 5 through the wedge shape prism 7. A transmitted beam 3 passes the wedge mold compensation plate 9, and is again returned to a beam splitter

through the recursive reflector 11 (reaching) and the wedge mold compensation plate 9. with the recursive reflector 13, it is reflected further, and the reflective beam 5 passes a beam splitter 7 again, and a transmitted beam 3 reflects it -- having had (beam) -- it joins together -- having -- two interference (beam) 15 and 17 -- ********. the beam according [ one plate which functions as a compensation plate ] to a beam splitter plate -- a variation rate and a deflection are neutralized.
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[Translation done.]